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By
Philip Worchel

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Space Perception and Orientation in the Blind

By

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TABLE OF CONTENTS

CHAPTER I

THE PROBLEMS[1]

CENTURIES of controversy and speculation concerning the sensory basis of spatial perception have yielded no decisive solution. The problem as conceived is not a feasible one for experimental test. To deprive a subject completely of tactile-kinesthetic sensitivity at birth, in order to determine its role in the development of spatial experience, is practically an impossibility.[2] Furthermore, to deprive an adult organism of a sense is not a valid procedure for determining the role of a sense organ in perception. It neglects the possibility of sensory compensation which may follow after years of sensory loss. Adding or subtracting sense organs experimentally may involve intersensory influences which must be considered in the interpretation of the results. Finally, the inadequate and limited tests of space perception employed, and the lack of controls, preclude valid generalizations. The tests must take into consideration the complex and multiple nature of spatial perceptions. Extensity, spatial order (including figures, directions, positions, magnitudes, and distances) and spatial relations—all must be considered under the general term of space perception. The analysis of experience into simple elements based upon isolated stimulations can give an oversimplified and distorted picture of the qualitative importance of individual sense organs.

Space perception is of sufficient practical and theoretical interest to warrant further experimentation on fundamental problems. By a systematic and carefully controlled study of the spatial perceptions of the totally blind and sighted individuals, we may determine the basis of the interrelationship of postural and distance-receptor mechanisms in spatial experiences. An investigation of the effect of age at blindness on space perception may reveal the role, if any, of visual experiences in space development.

[1] The cost of this investigation was met in part by a grant to the author by the Research Institute of the University of Texas.

[2] In Froriep's *Notizen* (1838) is to be found a detailed account, with a picture, of an Esthonian girl, Eva Lauk, then 14 years old, born with neither arms or legs, which concludes with the following words: "According to the mother, her intellect developed quite as fast as that of her brothers and sisters; in particular, she came as quickly to a right judgment of the size and distance of visible objects, although, of course, she had no use of hands" (Schopenhauer, *Welt a's Wille*, II, 44).

Chapter II

THE EXPERIMENTS

All the experiments reported here were performed at the Texas State School for the Blind, in Austin.[1] The first two series of experiments on form perception and spatial relations were conducted in a large unused classroom in the basement. The third experiment on space orientation took place on a 40 by 80-ft. concrete skating rink located behind the main building.

Of the 196 blind students at the School, 33 were classified as totally blind. These 33 *Ss* participated in all three series of experiments. The control group consisted of 33 sighted students from the public schools of Austin. They were matched on the basis of sex and chronological age. The blind *Ss* had been given

[1] Grateful acknowledgment is due to Mr. W. E. Allen, superintendent of the Texas State School for the Blind, for his co-operation in providing the subjects and facilities for the present study, and to Mr. W. T. Moore, graduate student in psychology, for assistance in testing the subjects.

TABLE 1

Age, Sex, and Age at Blinding for the 33 Blind, and Age and Sex for the 33 Sighted *Ss*

S No.	Blind				Sighted		
	S	Sex	Age (Yr.)	Age at Blinding (Yr.)	*S*	Sex	Age (Yr.)
1	SJ	F	8	1	LL	F	8
2	PP	M	8	Birth	PL	M	8
3	BT	M	8	3	AO	M	9
4	LP	M	9	6	BO	M	9
5	HG	M	10	Birth	TM	M	10
6	RS	M	10	Birth	CL	M	10
7	JE	F	10	Birth	CB	F	10
8	MH	F	11	Birth	MA	F	11
9	FM	M	13	Birth	RD	F	12
10	LB	F	14	2	LM	F	13
11	JC	F	14	Birth	JM	F	13
12	TC	M	14	6	JN	M	14
13	JL	F	14	6	DR	M	14
14	CM	M	14	10	GG	M	14
15	WM	M	14	Birth	BT	M	14
16	JB	F	15	7	WW	F	14
17	DC	F	15	Birth	HN	F	15
18	LM	F	15	1	JS	F	15
19	RM	M	16	9	BM	M	15
20	GK	M	16	7	TB	M	16
21	BW	M	17	11	GT	M	16
22	LS	F	17	Birth	KO	F	16
23	FC	F	17	Birth	TW	F	17
24	JF	M	18	5	JO	M	17
25	RF	M	18	Birth	ML	M	17
26	GH	F	18	Birth	FJ	F	17
27	JB	F	18	Birth	AI	F	18
28	JP	M	18	7	MH	M	18
29	GW	M	18	5	LC	M	18
30	RH	M	18	3	PP	M	19
31	JD	M	19	10	WA	M	19
32	WP	M	19	Birth	FT	M	20
33	SL	F	21	Birth	ED	F	20

the Hayes-Binet Intelligence Test. None of the blind received an IQ score below 85 or above 120. The school level of the blind Ss ranged from the second to the eleventh grade.

Table 1 shows the chronological age, sex, and age at blinding for the blind Ss, and the chronological age and sex of the sighted Ss. The mean age of the blind and sighted Ss was 14.67 years and 14.42 years, respectively, and the range was 8 to 21 years. There were 19 males and 14 females in each group. Sixteen of the blind Ss were congenitally blinded, 7 lost their sight before the age of 6, and 10 became blind after the age of 6 years.

The sighted Ss were transported to the School for the Blind, where the experimental areas were located. All the Ss, both the sighted and the blind, were securely blindfolded in all three series of experiments.[2]

Three aspects of space perception were investigated in the present study: tactual form perception, tactual space relation, and space orientation.

[2] The blind were blindfolded in order to eliminate any light perception that may have been present but not diagnosed by the oculist.

Chapter III

EXPERIMENT A: TACTUAL FORM PERCEPTION

A. Statement of the Problem

This study attempts to evaluate the ability of the blind to perceive tactual form. The methods of reproduction, verbal description, and recognition are employed. The procedures in the present experiment isolated the form component from all other object components such as weight, texture, and size. By matching our blind *S*s with sighted *S*s of the same age and sex, and by using totally blind individuals with varying durations of blindness, we hoped to determine the role of visualization in tactual form perception.

B. The Method

The form perception experiments consist of three parts. In Part 1 small blocks of simple geometrical shapes are manipulated in one hand; in Part 2 larger blocks are used and both hands are permitted to explore the object. The methods of reproduction (drawing) and verbal report (description) are employed. In Part 3 the method of recognition is used in selecting the stimulus block from four choice blocks.

1. *Small Forms: Reproductions and Verbal Report*

A set of nine blocks of three-ply wood was cut into the following shapes and dimensions: (1) square, 2 by 2 in., (2) circle, 1-in. radius, (3) equilateral triangle, 2-in. sides, (4) semicircle, 1-in. radius, (5) rectangle, 1 by 2 in., (6) quarter-circle, 2-in. radius, (7) parallelogram, 2-in. sides, (8) crescent, 2 in. from tip to tip, (9) ellipse, 1-in. and 2-in. radii.

These blocks were presented in the above order to the blindfolded *S*. The following instructions were given:

> I am going to hand you a number of objects one at a time. After I hand it to you, I want you to feel it with one hand so that you can remember the shape. When you lay it down, pick up the pencil which lies on your desk [*E* indicates pencil] and draw the shape to the best of your ability on the sheet of paper which lies in front of you.

The first object was then handed to *S*. When *S* placed the block on the desk, he picked up the pencil and drew the object (method of reproduction). He was then asked to name the form or describe it (method of verbal report). Then the second block was presented, and so on. The time between the presentation of the block to *S* and the return of the block to the desk was recorded. At no time, however, was *S* given any indication that speed was involved.

2. *Large Forms: Reproduction and Verbal Report*

The nine blocks of this test duplicated the forms of the first part, but the area of each block was three times that of the ones in Part 1. The procedure of administration and scoring was repeated. After the completion of Part 1, the following instructions were read to the *S*:

> This time I am going to hand you a number of larger blocks, one at a time. After I hand one to you, I want you to feel it with both hands instead of one so that you can remember the shape. When you lay it down, pick up the pencil and draw the shape to the best of your ability on the sheet of paper.

After *S* had drawn the form, he was asked to name or describe that form.

3. *Method of Recognition*

In using the method of recognition, we had to construct two sets of blocks of

identical forms but different sizes in order to isolate the form component from all other object components. The set of smaller blocks was used as the stimulus objects, and the second set (the larger blocks) was used as the response or choice forms. By this procedure, *S* could not use size and weight as cues for recognition. Texture and thickness were held constant by using .5-in. bakelite for all forms. The nine forms used in Part 3 were the same as those in Parts 1 and 2. The area of the choice blocks was twice that of the stimulus blocks.

The instructions for Part 3 were as follows:

> I am going to hand you a block. I want you to feel it so you can remember the shape. You may use one or both hands. When you lay the block down, I will hand you four blocks, one at a time. One of these four blocks has the same shape as the one you just felt. I want you to pick out the one of these four blocks that has the same shape as the first one. You may feel them as often as you like until you are sure that you have the one that has the same shape. Do you understand?

Since recognition depends not only on the difficulty of the perception of the stimulus form but on the degree of similarity of the other choice forms, we presented in almost every case rounded forms as choice blocks when the stimulus form was rounded, and cornered forms when the stimulus form was cornered. For example, when the stimulus form was a square, we presented a triangle, trapezoid, diamond, and square. When the stimulus form was an ellipse, we presented a semicircle, ellipse, circle, and crescent. Also, in every presentation, we included a choice form that was similar in some respects to the stimulus object. Thus, when the circle was the stimulus form, an ellipse was included in the choice forms. When the diamond block was the stimulus object, a square was presented with the choice forms. Introspections were requested from each *S* at the end of each experiment.

C. Results

1. *Standards for Rating Reproductions and Verbal Reports*

In order to rate the accuracy of the reproductions of the small and large forms in Parts 1 and 2, five standards were established. The letter grades, A to E, represented decreasing degrees of accuracy of the drawings. The size of the reproduction was ignored in the ratings. "A" was given for exact form reproduction. "B" denoted only one error; either the figure was not closed, or the lines crossed each other in one of the corners. When the corners of the form were rounded and either one of the errors listed for grade "B" was present, the reproduction received a grade of "C." "D" represented almost complete unrecognizability, and "E" showed no resemblance at all to the original form. Figure 1 shows the standards that were used in determining the ratings of the reproductions.

In evaluating the verbal reports or descriptions of the forms, three categories of accuracy were established. "Excellent" was assigned when the geometric form was named or when the angles and relationships of the individual parts were described. For example, in describing the square, *S* had to state that all the angles were right angles and all the sides were equal. "Fair" was given when one of the details was inaccurate. Thus, the right angles of the square might be mentioned, but the equality of the sides was omitted or the sides were described as unequal. When the description did not resemble the stimulus form, the report received the rating "poor."

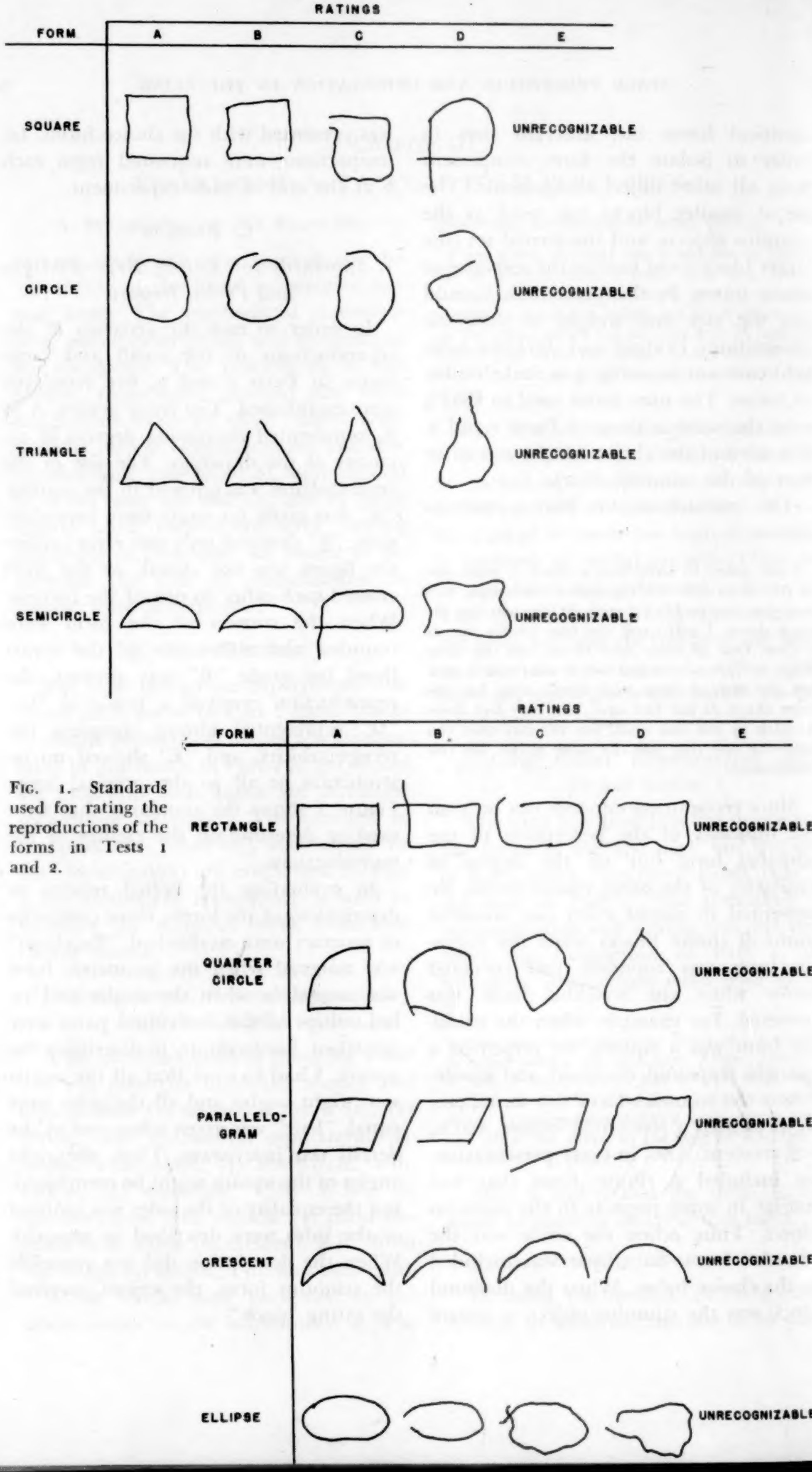

FIG. 1. Standards used for rating the reproductions of the forms in Tests 1 and 2.

TABLE 2

DISTRIBUTION OF THE RATINGS FOR THE REPRODUCTIONS OF EACH OF THE SMALL FORMS OF PART 1 FOR THE BLIND AND THE SIGHTED *Ss*

Form	Rating									
	A		B		C		D		E	
	Blind	Sighted	Blind	Sighted	Blind	Sighted	Blind	Sighted	Blind	Sighted
Square	0	4	6	26	12	3	5	0	10	0
Circle	0	8	8	16	11	9	10	0	4	0
Triangle	0	4	4	22	7	3	7	2	15	2
Semicircle	0	4	5	22	4	1	11	4	13	2
Rectangle	0	2	4	24	8	5	8	1	13	1
Quarter-circle	0	0	1	20	3	10	7	1	22	2
Parallelogram	0	2	2	16	6	10	1	3	24	2
Crescent	0	2	3	12	3	16	13	1	14	2
Ellipse	0	0	3	22	5	6	12	3	13	2
Total	0	26	36	180	59	63	74	15	128	13

No comments were made to *S* on the accuracy of the reproductions or verbal reports. All the ratings of the reproductions and verbal reports were made by *E* and his assistant. Strict adherence to the established criteria and standards was followed. At no time was there any serious conflict of rating or judgment. In making the ratings, care was taken to assure that *E* and assistant did not know to which group, blind or sighted, *S* belonged. In this way, experimental biases were minimized.

The results of the present experiment on form perception are shown in Tables 2, 3, and 4. Gross results for both the sighted and the blind *Ss* and fractionation of the results according to age at blinding, chronological age, sex, and stimulus form are included.

2. *The Method of Reproduction*

Table 2 shows the distribution of the ratings for each of the small forms for both the blind and the sighted *Ss*. Since the number of cases was the same for both groups ($N = 33$), direct comparisons can be made. The sighted obviously

TABLE 3

DISTRIBUTION OF THE RATINGS FOR THE REPRODUCTIONS OF EACH OF THE LARGE FORMS OF PART 2 FOR THE BLIND AND THE SIGHTED *Ss*

Form	Rating									
	A		B		C		D		E	
	Blind	Sighted	Blind	Sighted	Blind	Sighted	Blind	Sighted	Blind	Sighted
Square	1	8	4	20	11	5	8	0	9	0
Circle	0	8	6	18	17	7	7	0	3	0
Triangle	0	2	5	31	8	0	3	0	17	0
Semicircle	0	4	5	26	4	3	9	0	15	0
Rectangle	0	4	5	26	9	3	8	0	11	0
Quarter-circle	0	0	3	26	2	4	5	1	23	2
Parallelogram	0	0	0	16	4	12	7	5	22	0
Crescent	0	0	0	22	6	8	15	1	12	2
Ellipse	0	0	0	28	6	2	13	1	14	2
Total	1	26	28	213	67	44	75	8	126	6

TABLE 4

DISTRIBUTION OF THE RATINGS FOR THE VERBAL REPORTS OF EACH OF THE FORMS ON PARTS 1 AND 2 FOR THE BLIND AND THE SIGHTED *S*s

Form	Rating											
	Part 1						Part 2					
	Excellent		Fair		Poor		Excellent		Fair		Poor	
	Blind	Sighted	Blind	Sighted	Blind	Sighted	Blind	Sighted	Blind	Sighted	Blind	Sighted
Square	27	30	1	3	5	0	27	28	2	3	4	2
Circle	32	31	0	2	1	0	32	32	0	1	1	0
Triangle	23	30	5	1	5	2	24	32	3	1	6	0
Semicircle	26	28	4	1	3	4	27	33	1	0	5	0
Rectangle	26	28	5	3	2	2	26	32	2	1	5	0
Quarter-circle	15	22	11	8	7	3	13	26	15	4	5	3
Parallelogram	14	28	8	3	11	2	18	28	10	3	5	2
Crescent	16	26	11	3	6	4	18	28	9	2	6	3
Ellipse	24	30	3	1	6	2	26	28	2	3	5	2
Total	203	253	48	25	46	19	211	267	44	18	42	12

do much better than the blind.

Since the total ratings do not consist of independent observations (each *S* contributed nine ratings), the chi-square test cannot be applied directly to the totals for the blind and the sighted. The ratings on each of the nine forms, however, are independent. Since the theoretical cell frequencies of some of our five categories are less than 10, we combined the frequencies of the various categories for each form into two categories so that theoretical frequencies were all close to, or above, 10. The chi-square values for homogeneity of responses to each form were all greater than 12. The probabilities of obtaining such values by chance alone are all less than .001 ($df = 1$). For the individual forms, therefore, the sighted were consistently and significantly superior to the blind.

There were individual differences, however, in the accuracy of the reproductions for each form. The blind found the square and circle easier to reproduce than the other forms. The quarter-circle and parallelograms were the most difficult. For the sighted, the square was the easiest, and the crescent, most difficult.

Table 3 presents a similar picture for the larger forms. The sighted were significantly better than the blind in the reproduction of each of the nine forms. The chi-square values (after combining categories) for each form are all above 12. The probability of obtaining this value by chance is above .001.

The difficulty of the reproductions was similar to that of the small forms in Part 1. The circle and square were the easiest for the blind, and the parallelogram, crescent, and ellipse were most difficult. For the sighted, the square, triangle, circle, semicircle, and rectangle were easier to reproduce than the ellipse, crescent, or parallelogram.

There was practically no difference between the reproduction scores for the smaller and larger forms for the blind. The distributions of ratings for each form are almost identical (cf. Tables 1 and 2). For the sighted, however, there was a decided improvement when they were allowed to use both hands to manipulate the forms (Part 2). Table 2 shows that 206 reproductions of the small forms by the sighted *S*s received B or better. For the larger forms (Table 3), 239 reproductions were rated B or better. We cannot say whether this improvement was due to practice or to the use of two hands, inasmuch as we did not counterbalance the presentations of the smaller and larger forms. It is signifi-

cant, however, that the blind did not show such improvement on the larger forms.

3. *Method of Verbal Report*

The descriptions of the forms by the sighted are apparently superior to those by the blind. Table 4 gives for each form the frequency of the ratings "excellent," "fair," and "poor." In Part 1 (small forms), 203 of the 297 responses of the blind were rated excellent; 48, fair; and 46, poor. For the sighted, 253 responses were excellent; 25, fair; and 19, poor. The totals are misleading, however, since the superiority of the sighted appears only in the descriptions of the parallelogram and crescent in which the chi-square values (excellent vs. fair and poor) are greater than 8. The probability of obtaining this value by chance ($df = 1$) is less than .01. All other values for the remaining forms are not significant at the .01 level. The blind found it easier to describe the square and circle and more difficult to describe the parallelogram and quarter-circle. The sighted also found the quarter-circle more difficult to describe than the other forms.

The method of verbal report for the larger forms (Part 2) yields results similar to those of Part 1. Table 4 shows 211 ratings of excellent for the blind; 267 ratings of excellent for the sighted. The superiority of the sighted over the blind lies in their ability to describe more accurately the quarter-circle, the parallelogram, and the crescent. The chi-square values for these forms are significant at less than the .01 level when we combine the frequencies of the fair and poor categories. The relative difficulty of the forms in Part 2 is the same as that in Part 1 (smaller forms) for both the blind and the sighted *Ss*. The quarter-circle again appeared to be most difficult to describe for both groups.

The distribution of the ratings of the verbal reports of the blind in Part 2 is almost identical with that in Part 1 (cf. Table 4). The chi-square values (combining categories) for the individual forms of Parts 1 and 2 are all less than 1, and the *P*'s are above .50. We can conclude that for the blind the use of two hands in manipulating the forms does not give any significantly better descriptions than those obtained in handling the forms with only one hand. For the sighted, however, there is slight improvement when both hands are used, but the improvement is not significant. All the *P*'s of the chi-square values (with categories combined) for the ratings of the individual forms are above .20.

The time for the handling of the small forms by the blind is not significantly different from that taken by the sighted *Ss*. The mean for the blind was 9.9 ($SD = 8.52$) and for the sighted, 9.1 ($SD = 5.73$). The probability of obtaining a difference of .73 sec. by chance is between .40 and .50 ($t = .73$).

In Part 2, however, the sighted took much less time than the blind to handle the forms. The sighted required, on the average, 6.4 sec. ($SD = 2.85$ sec.) and the blind required 9.9 sec. ($SD = 8.52$ sec.). The difference of 3.5 sec. is significant at the .05 level. While the blind showed no improvement in time in Part 2 (9.9 sec.) over Part I (9.9 sec.), the sighted showed significant improvement. Their mean decreased from 9.1 sec. (Part 1) to 6.4 sec. (Part 2).

4. *Method of Recognition*

The results of the method of recognition show no difference between the

blind and the sighted *Ss* in the tactual perception of form. Only two blind *Ss* made one error each, and no errors were made by the sighted. One blind *S* (DC) selected the triangle when the stimulus object was the trapezoid, and another (JE) selected the triangle when the stimulus object was the quarter-circle. These incorrect choices are not absurd since there is some similarity among the trapezoid, quarter-circle, and triangles.

5. *Age at Blinding and Form Perception*

The significant superiority of the sighted over the blind *Ss* in the reproduction and verbal report tests suggests the importance of visualization in these methods of testing tactual form perception. If this hypothesis is true, then the accidentally blinded should reproduce and describe their tactual form perceptions more accurately than the congenitally blinded. Tests of significance and relationship confirm this hypothesis. Reproduction ratings were converted into numerical scores: A = 4, B = 3, C = 2, D = 1, E = 0. Verbal report judgments were also converted: excellent = 3, fair = 2, poor = 1. The mean reproduction score of the congenitally blinded ($N = 16$) in Part 1 was $2.38 \pm .47$, and for the accidentally blinded ($N = 17$), $2.66 \pm .37$. The difference of .28 is significant at almost the .05 level ($t = 1.87$). On the reproduction test in Part 2, the congenitally blinded had a mean of $2.33 \pm .40$, whereas the accidentally blinded had a mean of $2.79 \pm .28$. The difference of .46 is significant at less than .001 ($t = 3.83$). On the verbal report test in Part 1, the mean for the congenitally blinded was $.63 \pm .52$, and for the accidentally blinded, $1.36 \pm .90$. The t of the difference is 2.81, which is significant at less than the .01 level. On the verbal report test in Part 2, the t of the difference was 3.33, which is significant at less than the .01 level.

The r's between age at blindness and the scores on the reproduction and verbal report tests of Parts 1 and 2 support the hypothesis that sight may be an important factor in tactual form perception. The r's between age at blindness and reproduction scores of Parts 1 and 2 are .61 and .76, respectively; between age at blindness and verbal report scores, .45 and .62, respectively. These coefficients are significant at less than the .01 level. Though vision may be important as a factor in the development of the ability to reproduce and describe tactual form, it apparently is of no importance in tactual form discrimination when tested by the method of recognition inasmuch as the congenitally blinded did as well as the accidentally blinded and the sighted *Ss*.

6. *Chronological Age and Form Perception*

All the r's between the chronological ages of the blind and the test scores indicate no significant relationship. The r's between age and the reproduction scores and between age and verbal report scores of Part 1 were .18 and .22, respectively, and between age and the reproduction scores and between age and the verbal report scores of Part 2 were .24 and .17, respectively.

7. *Sex and Form Perception*

On the reproduction and verbal report tests of Parts 1 and 2, the differences in the means were in favor of the males, particularly on the reproduction tests, but the differences were not significant at the .05 level. The superiority of the males in the reproduction test, though

not significant, suggests that drawing performance rather than form perception may be at the basis of this sex difference. On the tests of verbal report and recognition, the females did as well as the males.

8. *Relationship between Reproduction Tests*

Comparison of the reproduction scores between Parts 1 and 2 showed almost no difference in the ratings of the individual forms for the blind. As we should expect, therefore, the *r* between these two tests is very high (.92). A score on either test represents the score on the other, and it may well be that the traits measured by these tests are identical even though movement is limited to one hand in Part 1.

9. *Relationship between Verbal Report Tests*

The homogeneity of the scores of the blind on the verbal report tests of Parts 1 and 2 should reduce the correlation coefficient. The *r* between these two sets of scores for the blind is .80. These correlation coefficients (reproduction and verbal report) indicate that more extensive kinesthetic activity in handling the blocks does not lead to better tactual form perception. It may be that with more difficult and complex forms, the use of two hands would lead to more accurate reproductions and descriptions.

10. *Relationship between Verbal and Reproduction Tests*

We should expect that *Ss* who excelled in form reproduction would give more accurate form descriptions. The *r*'s of .64 and .76 between the reproduction scores and verbal report scores of Parts 1 and 2, respectively, confirm this hypothesis.

11. *Reliability of the Tests*

Split-half reliability was determined by correlating odd vs. even items on the form tests of our 33 blind *Ss*. The split-half correlation for the reproduction scores on the small form (Part 1) was .93. The Spearman-Brown formula for the reliability of the whole test gave a coefficient of .96. The split-half correlation for reproduction scores on the large forms (Part 2) was .90. The reliability coefficient of the whole test was .94. The split-half coefficients indicate that the two halves (odd vs. even) are equivalent, that is, they are measuring the same trait or traits. The high reliability coefficient of the whole test shows that the scores are a reliable index of the ability of our *Ss* at the time of testing.

Since the verbal report scores are much more homogeneous, smaller split-half correlation coefficients are expected. For Part 1 (small forms), the split-half coefficient was .70, and the reliability of the whole test was .82. For Part 2 (large forms), the split-half coefficient for the verbal report scores was .57, and the reliability of the whole test was .73.

12. *Ss' Comments*

During the various tests the blind *Ss* were encouraged to describe or tell how they knew the form. Their reports seemed to fall into a consistent pattern. Those who lost their sight later in life resorted to visual imagery when they were drawing, describing, or selecting the form. Typical comments of this group were: "You get a mental picture," or "I just get the shape down in my mind," or "I get a vivid picture." The congenitally blinded, on the other hand, either found it difficult to describe their mental processes, or vaguely mentioned, "I get the shape," or stressed the "feel of

the shape." For example, JC said, "I remember the way it felt in my hand." HG stated, "I just feel the shape. It has a certain number of corners." On the recognition test, HG said, "If they were both the same size, they would fit. I think about what would fit what." WP mentioned, "I feel for the shape of it." On the recognition test, he added, "I think if figures had been more similar I would have had a hard time. We use raised figures in geometry."

The sighted invariably translated their tactile-kinesthetic impressions into visual imagery. Many of them just stated that they got a picture of the form as they felt it. The corners seemed much easier to distinguish. The rounded edge of the quarter-circle gave them trouble.

D. Discussion

The method of reproduction showed that the blind were far inferior to the sighted subjects and that almost half of the drawings of the blind were unrecognizable. With the method of verbal report, however, the blind did much better. Their descriptions indicated that they had perceived the forms fairly accurately. Their failures in reproducing the form, therefore, were not due to poor tactual perception but may have been due to lack of experience in drawing. Analysis of the results indicates, however, that the poor reproductions are probably due to the inability of the congenitally blinded *Ss* to translate tactile impressions into visual imagery. The significant difference in the reproduction scores between the congenitally and the accidentally blinded and the high correlation between age at blinding and reproduction scores confirm this hypothesis. Also, though the blind showed better tactual form perception with the method of verbal report, the significant relationship between age at blindness and verbal report scores indicates again the importance of visualization. The introspective reports show the predominant use of visual imagery by the accidentally blinded. The congenitally blinded reported no such imagery. Stout contends that "those who have been blind in their fourth year translate their tactile impressions into visual imagery as we ourselves do in the dark" (13, p. 474). He finds support for this position in Heller's *Studien zur Blindenpsychologie* (6).

Sylvester, using a form board test on 85 blind *Ss*, found that those who had no visual experience at all showed the least ability, and the longer *S* had retained his vision, the more successful he was in the test. He concluded that "those who have had visual experience retain their visual imagery and are assisted by it in the interpretation of their tactile impressions; and tactual imagery, even in those who have no other resource, is not as effective as a combination of tactual and visual imagery" (14, pp. 210 ff.).

The results on each of the forms show that the congenitally blinded had great difficulty in describing the quarter-circle, parallelogram, and crescent. It may be that visual imagery is particularly important in the synthesis of the individual tactile impressions of more complex forms. Most of the older writers have neglected the role of visual imagery in their conclusions that the remarkable feats of the blind are due to the extraordinary sensitivity of touch developed by compensatory functioning and attention. Identification of objects by the blind does not necessarily require a synthesis of tactile impressions into a composite whole. Identification may be

due to a prominent feature of the object, such as odor, weight, texture, and size. Stout disregards visual imagery and emphasizes synthetic touch:

In the case of simple and familiar things which they [the blind] have already often explored by active touch, they can at once recognize shape, size, etc., by merely passive contact. But when the objects are presented to them with which they are quite unfamiliar, it is found that for precise apprehension, analytic touch must be combined with synthetic. Synthetic touch alone without the aid of previous experience yields at most a general and schematic total impression. For instance, they can tell whether the object is round or angular, and whether it is regular or irregular, but for precise determination of its shape, analytic movements are required (13, p. 476).

Our results show that touch alone is not as efficient in the perception of, and response to, complex tactual form relationships as touch aided by visual images. Wundt reached the same conclusion that touch sensations alone could never suffice for the exact apprehension of spatial relations. Even though spatial properties of objects are apprehended by the movements of hands and fingers, "we always find that the blind do not apprehend even fairly simple relations with anything like the rapidity with which the perceptions of sight enable us to obtain an adequate idea of the most complicated figure. The sensations of touch and movement have to construct the object gradually for them out of its parts" (151, pp. 157 ff.).

On the test of form recognition, the congenitally blinded did as well as the accidentally blinded and the sighted *Ss*. The method of testing form perception is, therefore, important in any conclusions concerning the relative superiority of the blind and the sighted *Ss*. If we had used only the method of reproduction, we should have concluded that the blind are far inferior to the sighted. The method of recognition showed, however, that there is no difference between the blind and the sighted.

The recognition test does not require visual imagery since the congenitally blinded did as well as the accidentally blinded. The method of testing form perception, therefore, is important in determining whether visualization will be utilized. Recently, aviation selection tests have been constructed for the purpose of testing visualization, but scoring convenience and the requirement of objectivity have resulted in multiple-choice responses. It may be that this type of response eliminates the need for visualization. A recall or reproduction test may be more suitable.

It is difficult in any recognition test to determine what cues are involved. Lowenfeld (9) set out to construct tests to differentiate the visually minded from the haptic individual. He assumed that his test of visualization of kinesthetic experience, which involves the selection of one of five forms experienced tactually, detects the visually minded person. The congenitally blinded should do as well as his "visual" person if we may extrapolate from our results. Recognition may be due only to an awareness of the absence or presence of isolated prominent features. The similarity of the choice forms may determine the mental processes for correct identification. Discrimination rather than form apprehension may have been operating in our recognition test inasmuch as we dealt with simple geometric forms. More difficult tests with more similar choice forms may require visual imagery for correct recognition of form.

E. Summary and Conclusions

To determine the ability of the blind

and the role of visualization in tactual form perception, three tests were administered individually to a matched group of 33 blind and sighted *Ss*. In Test 1, a series of simple geometrical blocks was presented to one hand of *S*. In Test 2, larger blocks were used, and *S* was allowed to manipulate the blocks with both hands. Reproduction (drawing) and description of the blocks were given by *S* immediately after presentation. Test 3 utilized the method of recognition. Four choice blocks were given to *S* after each stimulus presentation. These choice blocks were of the same texture, but all, including the correct choice block, were larger than the stimulus block. This procedure compelled *S* to depend on shape, alone, apart from size, weight, and texture in his selection.

The results show that:

1. The sighted were significantly better than the blind in the reproduction and description of each of the blocks in Tests 1 and 2.

2. The accidentally blinded gave significantly better reproductions and descriptions than the congenitally blinded in Tests 1 and 2.

3. With the method of recognition, however, there was no significant difference between the blind and the sighted, and between the accidentally and the congenitally blinded. The scores for all the *Ss* indicated almost perfect tactual form perception.

4. There was a significant and high correlation between age at onset of blindness and the scores in Tests 1 and 2 for both reproduction and verbal report.

5. There was no significant relationship between the chronological age of the blind and the scores on Tests 1 and 2.

6. There was a slight but insignificant difference in favor of the male over the female blind with the method of reproduction in Parts 1 and 2, but no sex difference with the method of verbal report.

7. The introspective reports and the analysis of the results of age at blinding indicated that superior performance in tactual form reproduction and description was probably due to the translation of successive tactile impressions into a visual image of the total form. Visual imagery, however, did not result in superior performance in the recognition of tactual form.

Chapter IV

EXPERIMENT B: TACTUAL SPACE RELATIONS

A. Statement of the Problem

Important to the spatial adjustment of the organism is its ability to manipulate spatial cues imaginally and to orient itself with respect to external objects and directions. The second experiment in the present series deals with the ability of the blind to solve a spatial problem requiring the perception of form and the imaginal manipulation of spatial cues, and attempts to determine the role of visualization in such problems.

B. Method

The spatial problems selected are similar to those in the Minnesota Paper Form Board except that our forms are presented tactually. Essentially, the problem consists of presenting one part of a form to one hand and the second part to the other hand, and asking *S* what form would result if the parts were placed together.

1. *Apparatus*

The response blocks consisted of seven three-ply wood blocks of the following shapes: square, circle, equilateral triangle, semicircle, rectangle, trapezoid, and ellipse. The radii of the circle and semicircle were 1 in. and of the ellipse 1 and 2 in. The sides of the square and triangle were 2 in., and the rectangle and trapezoid measured 1 by 2 in.

The stimulus blocks consisted of two parts of a circle, semicircle, ellipse, square, rectangle, trapezoid, and triangle. Figure 2 shows the stimulus forms and the order of presentation.

2. *Instructions*

The following instructions were read to *S:*

Now I am going to hand you two forms, one in each of your hands. I want you to imagine what form would result if these two blocks were placed together, that is, alongside each other. When you lay them down, I will hand you four different forms, one at a time. You are to give me the one which you think you would get if you had placed the two smaller forms together. Do you understand?

3. *Procedure*

The method of recognition was employed.

Two stimulus forms were handed to the blindfolded *S.* Without giving any indication that speed was involved, the time of handling the two forms was recorded. When the stimulus forms were laid down, the four response forms were handed to *S* and he was asked, "Which of these four forms do you think you would get if you had placed the two smaller ones side by side?" Figure 2 shows the response forms and the order of presentation for each of the stimulus forms.

At the completion of the experiment, *S* was asked to tell how he knew which was the correct form.

C. Results

The results of the present experiment on the manipulation of space relations are shown in Tables 6 and 7. The distribution of errors for the blind and sighted *Ss* appears in Table 6. A fractionation of the results according to errors on each of the seven forms is shown in Table 7.

1. *Blind versus Sighted*

The significant superiority of the sighted over the blind *Ss* in the manipulation of space relations is evident from the distribution of errors in Table 5.

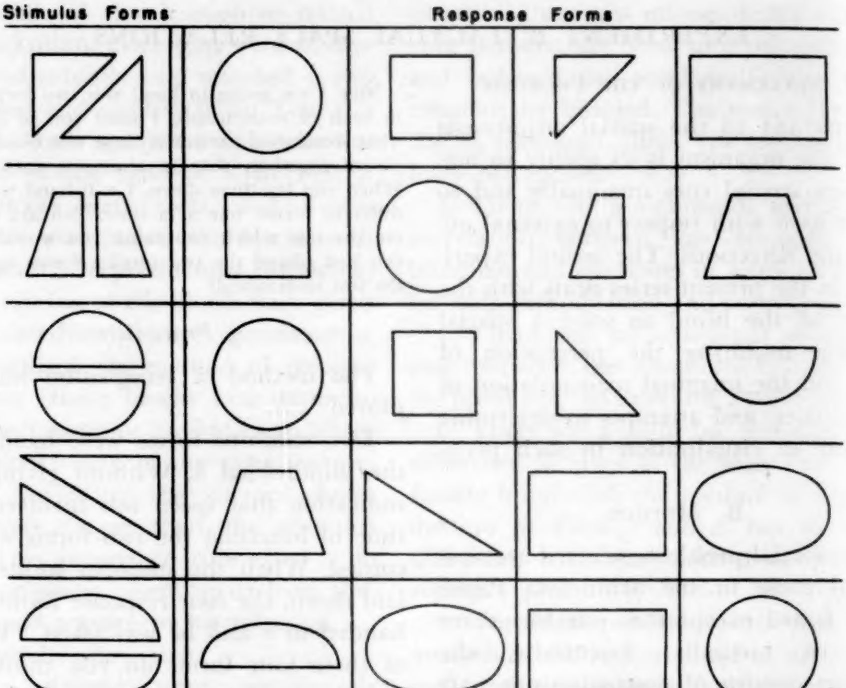

FIG. 2. The two parts of the stimulus forms and the four response forms presented in the spatial relations test

The range of errors for the blind is from 1 to 7; for the sighted, the range is from 0 to 4 errors. Almost half of the sighted *Ss* and only 15 per cent of the blind made 1 or 0 errors. The mean number of errors for the blind *Ss* was 3.26 ± 1.61, and for the sighted, 1.85 ± 1.40. The difference of 1.42 errors yields a t of 3.8, which is significant at less than the .001 level. Since this test is one of recognition, we cannot argue that the superiority of the sighted *Ss* is due to experience. It seems more likely that the use of visual imagery by the sighted *Ss* leads to better performance. If this is true, then the accidentally blinded who possess visual imagery should do better than the congenitally blinded.

Though the blind made more errors than the sighted, there was no significant difference between the two groups in the mean time taken to handle the stimulus

TABLE 5

DISTRIBUTION OF ERRORS ON THE SPACE RELATIONS TEST FOR THE BLIND AND THE SIGHTED *Ss*

Errors	Blind *Ss*	Sighted *Ss*
7	1	—
6	1	—
5	6	
4	6	4
3	8	4
2	7	9
1	4	14
0	—	2
Mean	3.3	1.9
S.D.	1.61	1.40
t	3.8	
P	< .001	

form. The mean time (sec.) for the blind was 15.7 ± 8.24, and for the sighted, 14.4 ± 9.04.

2. *Age at Blinding and Space Relations*

The results of the effect of age at blinding on the test scores confirm our hypothesis that visual imagery is a factor in our space relations test. The mean number of errors for the congenitally blinded was 4.00 ± 1.22, and for the accidentally blinded, 2.59 ± 1.61. The *t* of the difference is 2.76, which is significant at less than the .01 level. The superiority of the accidentally blinded, therefore, is probably not due to chance.

The relationship between age at blinding and the number of errors on the space relations test is significant also at the .01 level ($r = -.49$). This value is a conservative estimate of the correlation inasmuch as one of the variables, age at blinding, is quite homogeneous. Sixteen of our 33 blind *Ss* are congenitally blind. This inverse relationship indicates that the ability to deal with visual images in our accidentally blinded *Ss* leads to fewer errors on the spatial relations test. There was no difference, however, in the mean time for handling the stimulus forms between the congenitally blinded and the accidentally blinded. The mean time (sec.) for the congenitally blinded was 16.1 ± 8.1, and for the accidentally blinded, 15.3 ± 3.2. The *t* of the difference is .27, and *P* is between .70 and .80.

3. *Chronological Age and Space Relations*

The *r* between chronological age and the space relations score is .34. This coefficient is obtained in about 5 per cent of the cases and is thus indicative of a trend. The relationship, however, is positive, which means that the older the blind person, the poorer the score on the space relations test. In view of the negative correlation between age at blinding and space relations scores, and the positive correlation between chronological age and space relations scores, a more significant correlation would result between age at blinding and test scores if we eliminated the effect of chronological age. The partial correlation between age at blinding and test

TABLE 6

THE NUMBER OF ERRORS FOR EACH FORM IN THE SPACE RELATIONS TEST FOR THE BLIND AND THE SIGHTED *Ss*

Form	Frequency of Response Errors	
	Blind ($N = 33$)	Sighted ($N = 33$)
Square	17	4
Trapezium	12	5
Circle	3	0
Rectangle	22	9
Ellipse	5	1
Semicircle	31	30
Triangle	18	12
Total	108	61

scores with chronological age "removed" is .57. The partial correlation coefficient between chronological age and test scores with age at blinding held constant is .47. Both coefficients are significant at less than the .01 level.

4. *Sex and Space Relations*

The slight difference of .4 errors in favor of the males was not significant. We can, therefore, conclude that sex is not a factor in our test of space relations. There was also no significant sex difference in time scores.

5. *Form and Space Relations*

The easiest forms for both the blind and the sighted *Ss* to recognize from the tactual perception of the two parts were the ellipse and the circle. Table 6 shows that only 3 blind and none of the sighted made errors on the circle; and 5 blind and 1 of the sighted made errors on the ellipse. The most difficult form for both groups to recognize was the semicircle. They usually selected the original stimulus form, the quarter-circle. Almost all the blind (31) *Ss* missed this form; and surprisingly, 30 sighted *Ss* also missed this form. The rectangle and square seemed best to differentiate the blind from the sighted. Only 4 of the sighted missed the square, whereas 17 of the blind missed it. On the rectangle, 22 of the blind made errors, whereas only 9 of the sighted made errors.

6. *Reliability of the Test*

Split-half reliability of the space relations test was determined by correlating odd vs. even items. The split-half correlation coefficient was .72. The two halves of the test are equivalent. The reliability of the whole test was .84. We can, therefore, conclude that the scores at the time of the administration of the test were a reliable measure of the ability of the blind and the sighted to manipulate spatial relations.

7. *Ss' Comments*

Very few *Ss*, blind or sighted alike, could give any description of the mental processes involved in deciding what form would result if the parts had been placed together. The most frequent response was, "I don't know." Many *Ss* simply said, "I just knew." A few of the responses indicated that visual imagery of the response form did not occur on the handling of the stimulus forms. Rather, the images of the stimulus parts were elicited when the response forms were selected. As one *S* said, "I tried to imagine whether the parts could make up this form." The images of the parts were retained but the total form could not be visualized from the parts themselves. This is understandable in view of the fact that the blocks could be placed side by side in various ways to form different total patterns. It was only when the response forms were presented that *S* actually could decide whether the parts could make up a particular form.

D. Discussion

A number of facts in the present experiment testify to the importance of visual imagery in the tactual recognition of form when only parts of the form are presented. The sighted group is significantly superior to the blind, and the accidentally blinded make fewer errors than the congenitally blinded. Not only do the accidentally blinded do better, but those whose blindness occurred later make fewer errors, as indicated by the *r* between age at blinding and test scores. The low but significant correlation of

the chronological age of the blind with errors on the space relations test suggests that imagery becomes less vivid with increasing chronological age. This finding was originally reported by Galton, and later confirmed by Betts (1). A more reasonable explanation, however, is that the longer the blind person is deprived of vision, the less does he depend on visual imagery. In other words, richness and vividness of imagery may require periodic visual stimulation. The longer a person is deprived of visual reinforcement, the less vivid becomes his visual imagery. This explanation is supported by the partial correlation between chronological age and test scores as age at blinding is held constant.

Cutsforth (3), in an experiment on the relationship between tactual and visual perception, also showed the importance of visual imagery in tactual form perception. He concluded that tactual qualities provide "texture," "body," and subjective reference, but form, extent, position, and organization are visual.

Our present findings are not in agreement with the general conclusions of Czermak (4), Gärttner (5), and Brown and Stratton (2) that the blind are superior to the seeing in the tactile discrimination of space. We might think that the blind, because of greater dependence on touch and attention to tactile cues, would be superior. The method of measuring tactile perceptions and the age at blinding must be considered in any such conclusions. The present test shows that the tactual advantage is actually on the side of those who could see or translate tactile impression into visual imagery.

An analysis of the results of the blind and the sighted *Ss* on each of the forms in the present test shows that the stimulus form, the quarter-circle, proved most difficult. It is easy to understand why the blind found it so inasmuch as in experiment A they made most errors in reproducing and describing the quarter-circle and parallelogram. With the small quarter-circle (Part 1), 22 of the blind gave unrecognizable reproductions, and with the large form (Part 2) 23 of the blind gave unrecognizable reproductions. With the method of verbal report, only 15 of the blind could describe the quarter-circle accurately. It is difficult to explain, however, why the sighted *Ss* had equal difficulty with this form. In experiment A, 20 and 26 sighted *Ss*, respectively, received a rating of B in Parts 1 and 2 with the method of reproduction. At least 22 *Ss* gave excellent descriptions of the quarter-circle with the method of verbal report.

E. Summary and Conclusions

The first experiment dealt with tactual form perception. The *Ss* were required to draw, describe, and recognize simple geometric forms that were presented to one and two hands. In the present series, the *Ss* not only had to perceive form tactually, but they were required to imagine what shape would result if two blocks were placed together. The response consisted in selecting the resulting shape from four blocks.

The results show that:

1. The sighted made significantly fewer errors than the blind.

2. The accidentally blinded were significantly superior to the congenitally blinded in the imaginal manipulation of space relations.

3. There is a definite relationship between age at blinding and accuracy on the space relations test.

4. There is a significant partial corre-

lation coefficient between the chronological ages of the blind and error scores on the space relations test when the effect of age at blinding is held constant.

5. There is no significant sex difference on the space relations test.

6. Split-half reliability of the space relations test indicates that the scores are a fairly reliable index of the ability of the blind *Ss* at the time of the administration of the test.

7. The easiest forms for the blind and the sighted to recognize from the tactual perceptions of the individual parts were the ellipse and circle. The most difficult form to recognize was the semicircle when the stimulus forms were the two quarter-circles.

8. The few introspective reports that were given indicate that visual imagery in the sighted and in the accidentally blinded occurred during the process of handling the choice blocks. The *Ss* tried to imagine whether the individual parts previously experienced could make up a particular block.

9. The use of visual imagery is of definite aid to the sighted and to the accidentally blinded in imaginally manipulating tactual perceptions.

Chapter V

EXPERIMENT C: SPACE ORIENTATION

A. Statement of the Problem

It is the purpose of the present set of experiments to determine (*a*) the ability of the totally blind to orient themselves spatially, and (*b*) the role of visualization in spatial orientation.

B. Method

To make valid comparisons between the blind and sighted *S*s and to determine the role of visualization, we set up a novel spatial task in which auditory cues would not give undue advantage to the blind, who are accustomed to using these cues. The procedure used by other *E*s of having *S*s point to near and distant places, or point to compass directions, or indicate on maps certain prominent landmarks is not suitable inasmuch as interest and experience are heavily weighted in these tasks.

Our experiment took place on a large rectangular concrete area, 40 by 80 ft., located about 200 ft. behind the main building of the Texas State School for the Blind. This area was used by some of the blind students for a skating rink. The nearest object to the rink was a large oak tree that stood about 150 ft. from the south side of the rink. On this area, we indicated in chalk the corners of eight right isosceles triangles with the following hypotenuse dimensions: 8, 10, 12, 14, 16, 18, 20, and 22 ft. Two series of spatial problems were presented to each of the blind and sighted *S*s. Task 1 consisted in leading *S* along the two sides of the triangle. He was to return without guidance, via the hypotenuse path, to the starting point. In Task 2, *S* was led along the hypotenuse and he was to return to the starting point along the two paths which formed the legs of the triangle. In each task, the distance *S* stopped from the starting point was recorded to the nearest foot. At the beginning of the experiment we measured the angular deviation from the hypotenuse path. As these deviations correlated highly with the distance from the starting position, we eliminated the angular deviation measurements and recorded only the distance measurements.

The blindfolded *S* was brought to the experimental area and the following instructions for Part 1 were read by *E*:

> I am going to lead you by the arm in two directions on this concrete area. When I stop, I want you to turn around and walk back in a straight path to the place we started. I will again take you by the hand to another starting place and lead you once more in two directions. Again you are to return directly back to the starting place, and then stop. We will do this a number of times, and each time when we start I will tap you on the back so that you will know that this is the starting place. Do you understand? To make sure you know what we want you to do, we will show you the first time by leading you back to the starting point.

The *S* was then led along the two legs of the triangle, stopped, then told that this was the way he should walk back to the starting place. He was then led along the hypotenuse to the original starting position. For the following trials, after *S* had been led along the two paths, *E* said, "Now return to the starting place directly in a straight path like I showed you, and then stop."

The order of the trials according to the hypotenuse length was: 10, 14, 18, 20, 16, 12, 8, and 22 ft.

For Part 2, the instructions were:

> Now I am going to lead you in a straight line. When I stop, I want you to return to the starting point by such a path that you will make

a right angle before you return. In other words, we will do the reverse of what we just did. Instead of my leading you in two directions and you return by a straight path, I will lead you along the straight path and you will now return by two paths. I will show you again what I want you to do. Remember I will tap you on the shoulder each time that we start from a new starting place.

The *E* then led *S* along the hypotenuse path, paused, then continued to lead him along the two legs back to the initial position. If at any time *S* indicated by his actions that he did not understand the directions, the instructions and demonstration were repeated. This was necessary only for a few of the younger *Ss*.

The order of trials in Part 2 was the same as in Part 1. Introspective reports were requested of each *S*, blind or sighted, at the end of the experiment.

C. Results

The results of the present experiment on space orientation are shown in Tables 7 and 8. For both Parts 1 and 2, the means of the distances in feet between the starting position and the point where *S* stopped were calculated. The distribution of these mean distances for each *S* is given in Table 7. In Table 8, the mean distances and standard deviations in feet between the "start" and "stop" positions for each hypotenuse distance are shown.

1. *Blind versus Sighted*

The significant superiority of the sighted over the blind *Ss* is evident from Table 7. For Part 1, in which *S* was required to return by way of the hypotenuse, the mean distance by which the blind *Ss* missed the starting position is 6.30 ± 2.76 ft. The sighted *Ss* in the same test missed the initial position by 4.66 ± 1.71 ft. The t of the difference is

TABLE 7

Distribution of the Mean Distances (in Feet) in Missing the Starting Position on the Space Orientation Tests of Parts 1 and 2 for the Blind and the Sighted *Ss*

Mean Distance	Part 1		Part 2	
	Blind	Sighted	Blind	Sighted
16	1		1	
14	—		—	
12	—		1	
10	3		1	
8	4	2	7	4
6	14	10	13	8
4	6	13	8	13
2	5	6	2	6
0	—	2	—	2
Mean	6.3	4.7	6.8	5.0
SD	2.76	1.71	2.61	2.11
t	2.88		3.03	
P	.001–.01		.001–.01	

significant at less than the .01 level. On Part 2, where the *Ss* returned to the starting point via the right-angle path, the mean for the blind was 6.78 ± 2.61, and for the sighted, 4.99 ± 2.11 ft. The t of the difference (3.03) is significant at less than the .01 level. The range also shows some interesting differences. In both tests (Parts 1 and 2), two of the sighted *Ss* always returned within 2 ft. of the starting position. None of the blind could achieve this level of excellence. None of the sighted missed the starting position by more than a mean distance of 10 ft., whereas the blind ranged up to a mean distance of 18 ft.

2. *Age at Blinding and Space Orientation*

Both the t test of significance between the distance scores of the congenitally blinded and accidentally blinded, and the product-moment correlation between age at blindness and distance scores show that age at blinding is not a factor in our tests of space orientation.

TABLE 8

MEAN DISTANCES AND STANDARD DEVIATIONS (IN FEET) IN MISSING THE STARTING POSITIONS ON THE SPACE ORIENTATION TESTS OF PARTS 1 AND 2 FOR THE BLIND AND THE SIGHTED *Ss* ON EVERY HYPOTENUSE DISTANCE

Hypotenuse Distances (in Feet)	Part 1				Part 2			
	Blind		Sighted		Blind		Sighted	
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
8	4.1	4.15	2.4	1.11	4.0	2.66	2.6	1.53
10	3.6	1.74	2.6	2.27	4.1	2.07	2.6	2.08
12	5.8	4.99	4.4	1.79	5.9	3.58	4.1	2.95
14	4.7	2.81	3.7	1.86	5.8	3.62	5.6	3.34
16	7.0	4.48	4.2	2.03	7.6	3.68	4.5	2.37
18	6.7	3.36	5.6	3.02	8.3	3.75	5.3	2.91
20	8.5	4.45	6.9	3.43	9.3	4.16	6.4	3.60
22	9.9	6.88	7.4	4.29	10.2	4.84	8.2	4.46

In Part 1, the mean distance from the starting positions for the congenitally blinded was 6.48 ± 1.99 ft., and for the accidentally blinded, 6.16 ± 3.25 ft. The t of the difference in the means is .33 and the P is between .70 and .80. In Part 2, the mean for the congenitally blinded was 6.40 ± 1.35 ft., and for the accidentally blinded, 7.14 ± 3.37 ft. The probability of obtaining the t of .81 by chance is between .40 and .50.

The r between age at blinding and the distance scores in Part 1 was $-.22$. This negative correlation is not significant at the 5 per cent level. The correlation coefficient with the distance scores in Part 2 is .10 and, again, shows no significant relationship between age at blinding and the space orientation scores.

3. *Chronological Age and Space Orientation*

The r's of chronological age with the distance scores on the space orientation tests of Parts 1 and 2 are $-.12$ and .26, respectively. These coefficients are not significant at the 5 per cent level. We can therefore conclude that chronological age is not a factor in the present tests of space orientation.

4. *Sex and Space Orientation*

The mean distance score for the female blind *Ss* ($N = 14$) was 7.49 ± 3.11 ft., and for the male blind *Ss* ($N = 19$), 5.44 ± 2.11 ft. The t of the difference is 2.05, and P is between .05 and .10. Though the difference is not significant enough to conclude that there is a real sex difference, it is suggestive of a trend in favor of the male *Ss*. On Part 2, however, the difference is too slight in favor of the male *Ss*, and we can be fairly certain that on this test there is no sex difference.

5. *Distance and Space Orientation*

To determine whether any relationship exists between the distance *S* was removed from his starting position and his error in missing the initial position, the means and standard deviations in feet of the "error" or distance scores were calculated for every hypotenuse distance in Parts 1 and 2 for both the blind and the sighted *Ss*. The results are shown in Table 8. For every hypotenuse distance, the sighted did better than the blind; that is, the sighted returned closer to the starting position than did the blind. The performances of the

sighted were also more consistent. In almost every case, the standard deviations of the means for every hypotenuse distance were smaller than those of the blind.

Table 8 also shows that as the hypotenuse distance increased the mean "error" in missing the starting position increased for both the blind and the sighted *Ss*. For the blind, however, there was no noticeable increase in the distance for Parts 1 and 2 until after the 14-ft. hypotenuse distance. On the other hand, for the sighted *Ss*, there was no consistent increase until after the 16-ft. hypotenuse distance.

6. *Relationship between Space Orientation Tests*

It is surprising that in view of the almost identical means for the blind and the sighted in Parts 1 and 2 for each of the hypotenuse distances (Table 8), there is practically no relationship between the two space orientation tests. The product-moment correlation between distances of Tests 1 and 2 for our 33 blind *Ss* is only .13. We can be fairly certain, therefore, that we are not measuring the same traits in these two tests.

7. *Reliability of the Tests*

Since the space orientation tests contain items which differ in difficulty, that is, larger errors in missing the starting positions occur with the greater hypotenuse distances, we correlated the results of the 8-, 12-, 16-, and 20-ft. hypotenuse distances with the results of the 10-, 14-, 18-, and 22-ft. distances. The split-half correlation of the halves is .74. The reliability of the whole test is .85. For Test 2, the split-half coefficient of correlation is .71. The reliability of the whole test is .83. These coefficients indicate that the two halves of each test are equivalent, and that at the time of the administration of the tests, the scores were a fairly reliable measure of the ability of the blind to orient themselves spatially.

8. *Ss' Comments*

Most of the comments of the blind and the sighted *Ss* did not reveal the mental processes involved in the space orientation tests. Many *Ss* stated, "I don't know." Others said, "I just knew which way to walk and when to stop." A few of the comments, however, indicated that both the blind and the sighted *Ss* estimated the time it would require to return to the original starting position. None of the blind could tell how he knew the direction in which the starting point was located. A few of the sighted, however, mentioned that they had a vague picture of the location of the initial position. In the first test, their visual impressions became especially clear when *E* led them from the first leg to the second leg of the triangular path. It seemed when they started out from the initial position along a straight path, the direction of walking was important. As soon as they "turned off this straight path to follow along the second path," they "tried to keep in mind just about where the starting position was located." In the second orientation test, these few sighted *Ss* reported that after *E* had led them along the straight path, they had a "picture of the right-angular path which they were going to follow on returning to the initial position."

D. Discussion

The results of the first two experiments on tactual form perception and space relations demonstrated the important role of visual imagery. In the pres-

ent tests of space orientation, however, though the sighted excelled the blind Ss, we found no difference between the accidentally and the congenitally blinded, and no correlation between age at blinding and test scores. What cues did the blind use, and why did the sighted do better than the blind?

An analysis of the errors of the blind shows that the "missing" of the initial position did not lie so much in the length of *S*'s return path as it did in the angular deviations. They did not overshoot or undershoot the starting position, but their path deviated much more from the correct path than did that of the sighted. Their error, therefore, lay not so much in the estimation of the distance to the starting position as in direction. From the few introspective reports we received, apparently both the blind and the sighted estimated the distance by estimating the duration of walking. The sighted, however, probably translated the kinesthetic cues into visual images, and were better able to detect the correct direction. For some reason, the accidentally blinded, who in the first two experiments utilized visual imagery, did not do so in the present space orientation tests. It may be that in their movements about the environment, they have come to depend upon auditory cues or upon guidance by people or artificial aids (seeing-eye dog, cane, etc.) for directional orientation. In the present tests, reflected auditory cues were eliminated by selecting an experimental area free from objects. No guidance or other aids were given to the blind in their return to the initial position.

Investigators have concluded from the experiences and behavior of the blind in spatial orientation that the blind do not possess a spatial concept. Platner, in his *Philosophische Aphorismen,* states that "in reality to the blind, time serves instead of space" (12, p. 466). Lotze (8) mentions that the space of the blind may not be so much what is generally meant by space, as it is an artificial system of conceptions of movement, time, and effort.

Mellone and Drummond (10) agree with Mill's statement regarding great distances of time, rather than space, serving the blind. The fact, however, that the blind may use time in space orientation does not necessarily signify that their conception of space is radically different from that of the sighted. Ordinarily, the blind utilize auditory cues. It may well be that if we had provided some objects in our experimental area, the blind would have done as well as, or perhaps better than, the sighted. Pillsbury states:

> . . . for the blind, the auditory perception of space is much more important than for the seeing individual. They are more accurate in localizations of sound, and use sound to obtain an idea of the space in which they are walking, and of the distance of obstacles. It is said that the blind ordinarily refer their larger spaces to auditory qualities, as we refer them to vision. In all respects, perception of space by the ear follows the same law as the perception by the eye or skin (11 pp. 231 f.).

James (7) also emphasizes audition in the space concept of the blind:

> In taking a walk through the country, the mutations of sound, far and near, constitute the chief delight of the blind. To a great extent, their imagination of distance and of objects moving from one distance to another seems to consist in thinking how a certain sonority would be modified by the change of place (7, p. 205).

Investigations of the space orientation of the deaf-blind may yield more basic clues to the sensory basis of the space perception and orientation.

E. Summary and Conclusions

To determine the cues involved and the ability of the blind to orient themselves spatially, two tests of orientation were administered to the blindfolded blind and blindedfold sighted *Ss* in an outdoor experimental area relatively free from objects in the near vicinity. In the first test, *S* was led by *E* along two legs of a right triangle. The *S* was instructed to return in a straight path to the starting position, that is, along the hypotenuse. In the second test, *S* was led along a hypotenuse path by *E*, and *S* had to return to the starting position in a right-angle path. Seven different distances were used in each test. The results showed that:

1. The sighted were significantly better than the blind, that is, they returned closer to the starting position.

2. There was no difference between the congenitally blinded and the accidentally blinded on the space orientation tests.

3. There was no significant relationship between age at blinding and space orientation scores.

4. There was no significant relationship between the chronological ages of the blind and the space orientation scores.

5. There was no significant difference between the space orientation scores of the male and the female blind *Ss*.

6. The error in missing the starting position increased for both the blind and sighted *Ss* as the hypotenuse distance increased.

7. The few introspective reports given by the *Ss* indicated that both the blind and the sighted used *time* in estimating the distance from the starting position; but the sighted used visual imagery in determining the direction of the starting position and the returning path.

These results lead to the conclusion that in the absence of auditory cues, the blind rely primarily on *time* for distance estimation. Kinesthetic cues without the aid of visual imagery resulted in poor directional orientation. The sighted *Ss*, in the absence of visual cues, use both time and visual imagery for estimating distance and direction.

Chapter VI

GENERAL SUMMARY AND CONCLUSIONS

THE ROLE of visualization in the ability of the blind to perceive and manipulate spatial relations tactually and to orient themselves spatially was investigated in the present series of three experiments. In the first experiment we employed the methods of reproduction, verbal report, and recognition in testing the tactual perception of simple geometric forms. The second experiment dealt with problems of imaginally constructing a total form from the tactual perception of two parts of the form. Space orientation was studied in the third series of experiments. The *S* was to return to an initial starting position via a straight path after having been led in a right-angle path, and via a right-angle path after having been led along a straight path.

Two groups of 33 totally blind and 33 sighted *Ss* matched on the basis of sex and chronological age were used in the investigation. The results were fractionated on the basis of age at blinding, chronological age, and sex. Reliability of all the tests was determined by the split-half technique. On the basis of the present results we can conclude that:

1. The sighted *Ss* are superior to the blind in tactual form perception measured by reproduction and verbal report, in the imaginal manipulation of space relations, and in space orientation.

2. The blind do as well as the sighted in the recognition of tactual form.

3. The accidentally blinded surpass the congenitally blinded in tactual form perception (reproduction and verbal report) and in the space relations test, and equal the congenitally blinded in the recognition of tactual form and in space orientation.

4. There is a significant and high correlation between age at blinding and tactual form reproduction and description, and in the manipulation of space relations.

5. Sex differences are in favor of the males, but the differences were not significant in any of the tests.

6. For the blind Ss chronological age is significantly related to performance in the space relations test; in all the other tests, there is no relationship between chronological age and performance.

7. The ability to translate tactile-kinesthetic impressions into visual imagery gives significantly better scores in all of the tests of form perception except recognition and space orientation.

8. In the space orientation tests, visual imagery is important in directional orientation, but the estimation of time is fundamental in distance orientation for both the blind and the sighted *Ss*.

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